Earth Orbiter 1 (EO-1) Spacecraft Advanced Land Imager (ALI) to Spacecraft RS-422 Data Interface Control Document

National Aeronautics and
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Goddard Space Flight Center
Greenbelt, Maryland

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Earth Orbiter-1 (EO-1) Spacecraft Advanced Land Imager (ALI) to Spacecraft RS-422 Data Interface Control Document

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TBD List

Issue	Section Number	Resolution Date	Comment
Maximum number of connector mates/demates	2.7.3		
Maximum differential delay between any two RS-422 transmitters/receivers			
RS-422 receiver/transmitter operating temperatures			

Change Information Page

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Revision	Description	Date	Approval
–	Initial Release		3/30/98

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Section 1. Overview

1.1 Scope

This interface control document (ICD) defines the RS-422 data interface between the Earth Orbiter-1 (EO-1) Advanced Land Imager (ALI) instrument and the EO-1 spacecraft. The RS-422 data interface between the EO-1 Linear Etalon Imaging Spectral Array/Atmospheric Corrector (LEISA/AC or AC) instrument and the EO-1 spacecraft is defined in a separate document.

1.2 Supporting Documents

ALI-S1002	Focal Plane Subsystem to Instrument Interface Control Document (EO-1 Advanced Land Imager), Massachusetts Institute of Technology/Lincoln Laboratory (MIT/LL), 1997
AM-149-0020(155)	System Level Electrical Requirements NMP EO-1 Flight, Litton Amecom, 1996
	EO-1 Advanced Land Imager Design Convergence Review, 1997 (source: EO-1 Web page)
EIA-422-B	Electrical Characteristics of Balanced Voltage Digital Interface Circuits, EIA, 1994
TBD#; Rev. D	WARP to Ground ICD, GSFC, 1997

1.3 Requirements

Figure 1-1 shows the EO-1 Flight Data System architecture. The RS-422 data interface transfers raw high-rate science data from the ALI to the spacecraft. Specifically, the RS-422 data interface transfers science data from the ALI's Focal Plane Electronics (FPE) to the spacecraft's Instrument Fiber Optic Data Bus (FODB) Terminal and Wideband Advanced Recorder/Processor (WARP).

The RS-422 data interface can operate in the following configurations:

- ALI-to-WARP via a passive feedthrough in the powered-down Instrument FODB Terminal
- ALI-to-Instrument FODB Terminal, where the RS-422 data interface is converted to an FODB interface
- ALI-to-WARP through a direct connection, which would occur if the Category 3 Instrument FODB Terminal is not integrated into the spacecraft

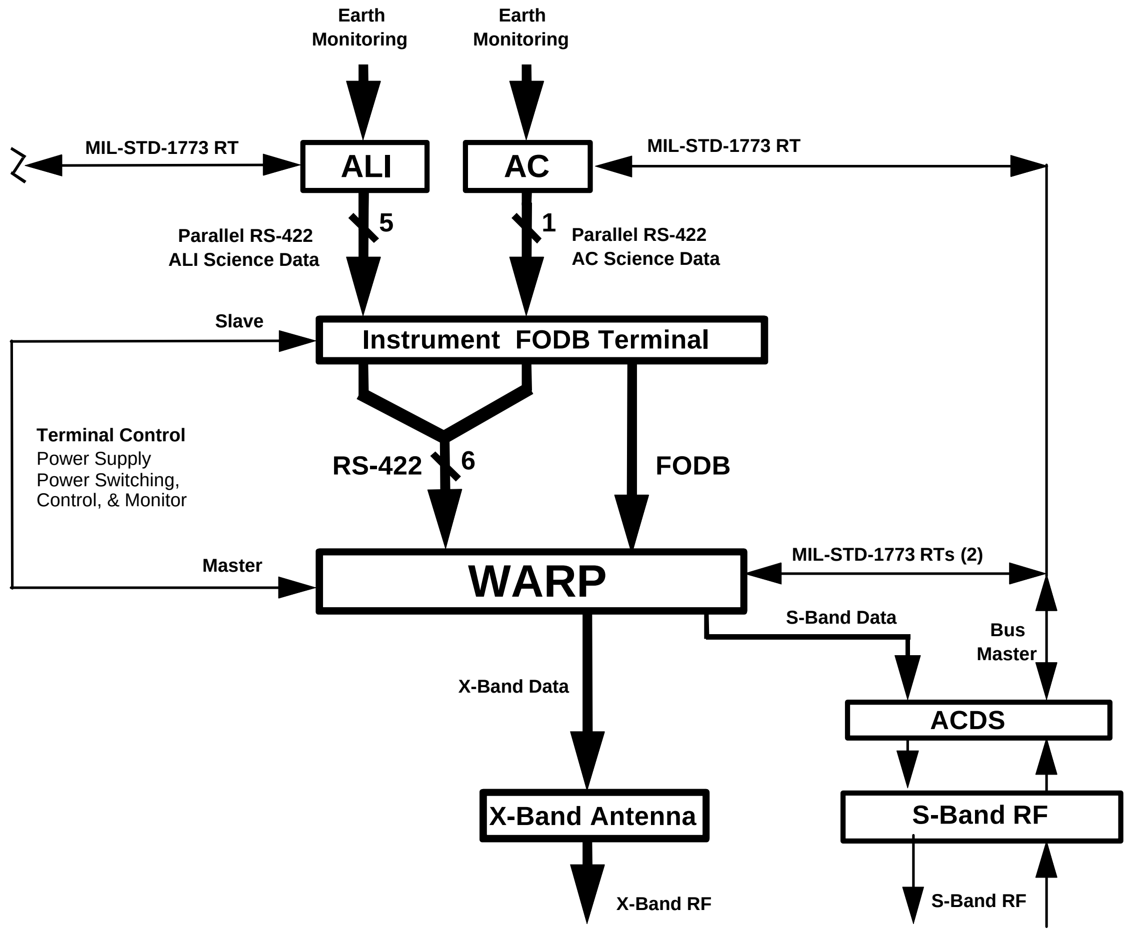


Figure 1-1. EO-1 Flight Data System Architecture

1.4 Interface Description

Figure 1-2 illustrates the interfaces from the ALI to either the Instrument FODB Terminal or the WARP.

Five separate RS-422 parallel data interfaces, each corresponding to a particular detector, exist between the ALI and the spacecraft: MS/PAN (3.2 MHz), WIS VNIR (4.8 MHz), WIS SWIR (9.6 MHz), GIS VNIR (4.8 MHz), and GIS SWIR (9.6 MHz). In Figure 1-2, each data interface is assigned a port number. Whenever the ALI's Focal Plane Assembly (FPA) is commanded to transmit data, all five ALI ports will be active.

Each data port contains 1 clock line and 32 data lines. Data are transferred sequentially across the port in 32-bit parallel data words. Each word consists of 24 bits of pixel data (two 12-bit pixels) and 8 bits of auxiliary data. The data format will be transferred in its “raw” form across the interface. The WARP and the Instrument FODB Terminal shall not be powered simultaneously.

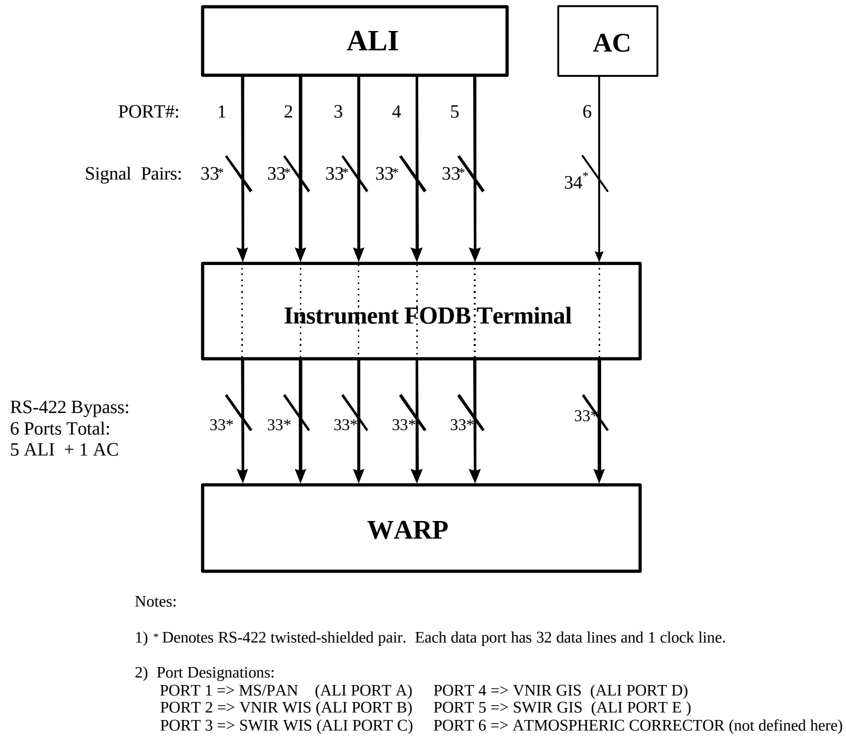


Figure 1-2. ALI RS-422 Interfaces

During any data collection mode, only one RS-422 receive interface (the WARP or the Instrument FODB Terminal) shall be powered. WARP and FODB Terminal operation shall be invariant to ALI data collection modes. For all ALI sensors, except the MS/PAN, “dead words” located within each valid frame shall be filtered. The WARP and FODB Terminal dead-word filtering scheme shall remain constant throughout all science data acquisition, test pattern, and calibration modes.

1.5 Interface Layers Description

This document will use a modified Open Systems Interconnection (OSI) standard model that describes an interface between two systems. Each system performs functions that can be described as a series of layers. Each system has the same number of layers. The equivalent layers for each system have the same functions and communicate via an established protocol that is transparent to the protocols at the other layers. Each system passes data from its upper layers to its lower layers via a service provided by the next lower layer.

OSI uses seven layers to describe an interface; for this document three layers are used: the Physical Layer (Layer 1), the Data Link Layer (Layer 2), and the Application Layer (Layer 3). The first two layers are identical to those of the OSI standard, and the third layer corresponds to the application-specific data structures of the serviced item. Figure 1-3 illustrates the layer concept.

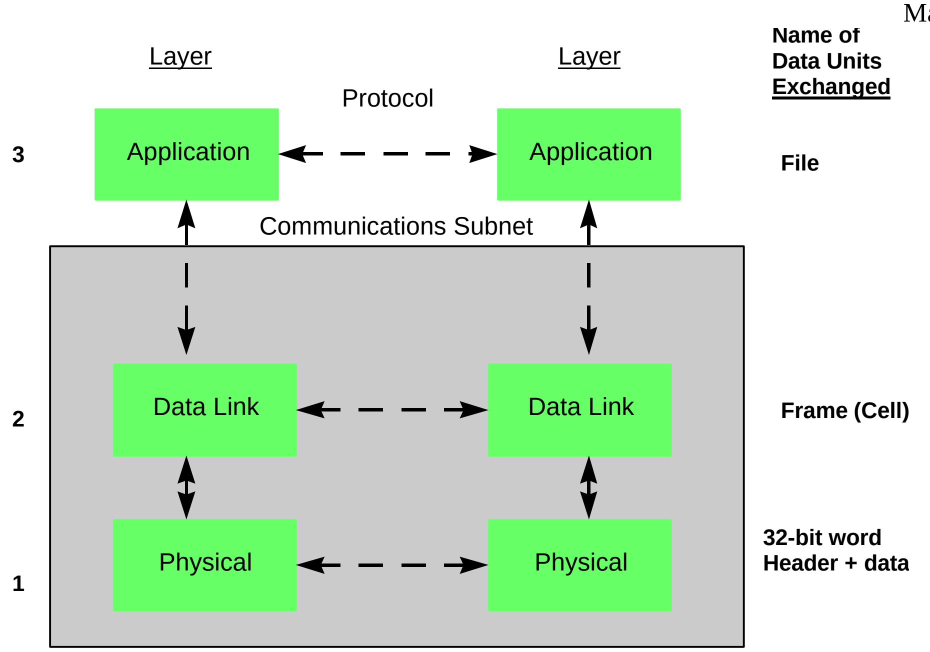


Figure 1-3. OSI Layer Concept

Section 2. Physical Layer

2.1 Function

The Physical Layer consists of two parts: the physical layer medium (the cabling and connectors, etc.) that makes up the physical connection between the two systems and the physical layer protocol that defines the lowest level of formatting (bit-level) of the data.

2.2 Cable Type

2.2.1 Maximum Cable Length/Terminations

The maximum, 24 AWG twisted-shielded pair cable length from the ALI to the WARP on the EO-1 spacecraft is 12 feet. The maximum cable length includes the length between the entry and exit connectors within the Instrument FODB Terminal. Maximum cable lengths were determined from the RS-422 test bed results (06/30/97) and EIA-RS-422 standard. In addition, all wires used within the same port (parallel word interface) shall be routed along the same path, assuring similar cable lengths for all bits within the same words. With the exception of the shortwave infrared (SWIR) WIS/GIS clock signals, all WARP RS-422 receiver termination impedances shall be AC coupled with 120-ohm resistor values in series with 100 picofarad capacitor values. The SWIR WIS/GIS clocks will be terminated with 120-ohm resistors. Termination impedance values were determined from the RS-422 test bed results (06/30/97).

2.2.2 Wire Gauge and Impedance

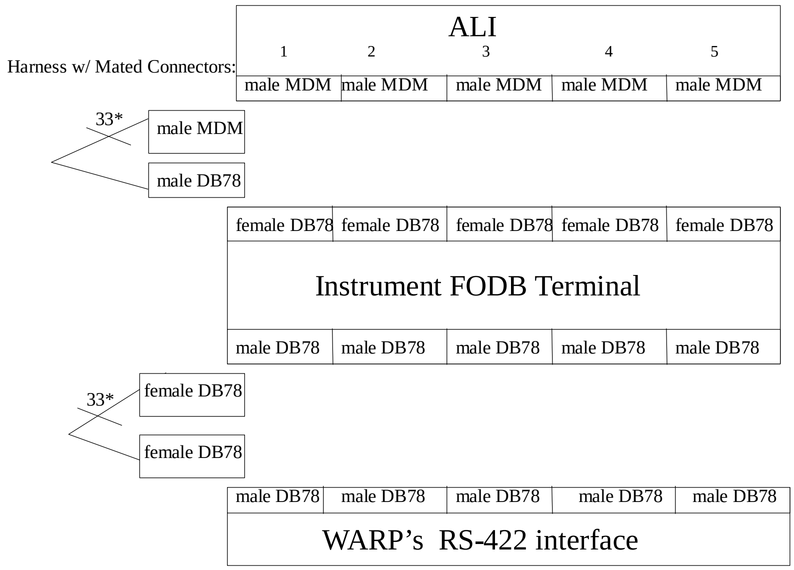
Each signal shall be conveyed via a 24 AWG twisted-shielded pair cable. The characteristic impedance of the twisted-shielded pair cables shall be 120 ohms.

2.2.3 Shield Connections

All shields shall be terminated to the backshells of the connectors on both ends of the harness run. Both ends of each RS-422 cable between the ALI and the Instrument FODB Terminal shall have backshells. Due to space limitations, both ends of the RS-422 cable between the WARP and the Instrument FODB Terminal shall be terminated with conductive tape.

2.3 Connector Type

Five male DB78 connectors interface the ALI data ports with the Instrument FODB Terminal. Each ALI data port shall mate to the EO-1 spacecraft via a harness with an MS24308-series DB78 connector. All male-type connectors shall have the GSFC part number 311P407-5P-B-12. All female-type connectors shall have the GSFC part number 311P407-5S-B-12. The Instrument FODB Terminal shall have female-type DB78 connectors, requiring the harness to use mating male-type DB78 connectors. The Instrument FODB Terminal’s RS-422 bypass shall have male-type connectors, requiring the harness to use mating female-type connectors. The WARP’s RS-422 interface shall have male-type DB78 connectors, requiring the harness to use mating female-type DB78 connectors. Due to limited connector space, the harness’ female-type DB78 connectors that mate to the WARP's RS-422 interface shall not have EMI backshells. A block diagram of the connector types is illustrated in Figure 2-1.



* Denotes RS-422 twisted-shielded pair. All ports within a box will have the same type matching harness connectors. Each ALI port shall have a harness with a mated male connector. Each WARP port shall have a harness with a mated female connector. Each Instrument FODB Terminal port that interfaces to the ALI shall have a harness with a mated male connector. Each Instrument FODB Terminal port that interfaces to the WARP shall have a harness with a mated female connector.

Figure 2-1. Connector Type Block Diagram

2.3.1 Connector Pin-Out

For ALI 100 MDM connector pin-outs, reference the Focal Plane Subsystem to Instrument ICD, MIT/LL document ALI-S1002.

Table 2-1 lists the pin-outs of the Instrument FODB Terminal's RS-422-to-ALI connectors, the Instrument FODB Terminal's RS-422-to-WARP connectors, and the WARP's RS-422-to-Instrument FODB Terminal RS-422 connectors. The pin-outs of the ALI science data interface can be found in the MIT/LL document ALI-S1002.

2.4 Bit-Level Timing

Every ALI data port has a 32-bit data word. Due to electrical variations in the RS-422 transmitters, the bit-level timing of each word may differ from port to port. Throughout the ALI's operating temperature range, the timing skew between any two RS-422 transmitters within the same data port shall not exceed 10 ns. Differential delays between data signals within a given data port (from the ALI) will cause bit arrival time variations at the FODB/WARP RS-422 receivers.

Table 2-1. Pin-Outs (1 of 2)

Pin #	Signal Name[1]	Description
1	WP“N”DB00P	Data bit 0 - MSB positive
20	NC	No connect
21	WP“N”DB00N	Data bit 0 - MSB negative
2	WP“N”DB01P	Data bit 1 - positive
22	WP“N”DB01N	Data bit 1 - negative
3	WP“N”DB02P	Data bit 2 - positive
23	WP“N”DB02N	Data bit 2 - negative
4	WP“N”DB03P	Data bit 3 - positive
24	WP“N”DB03N	Data bit 3 - negative
5	WP“N”DB04P	Data bit 4 - positive
25	WP“N”DB04N	Data bit 4 - negative
6	WP“N”DB05P	Data bit 5 - positive
26	WP“N”DB05N	Data bit 5 - negative
7	WP“N”DB06P	Data bit 6 - positive
27	WP“N”DB06N	Data bit 6 - negative
8	WP“N”DB07P	Data bit 7 - positive
28	WP“N”DB07N	Data bit 7 - negative
9	WP“N”DB08P	Data bit 8 - positive
29	WP“N”DB08N	Data bit 8 - negative
10	WP“N”DB09P	Data bit 9 - positive
30	WP“N”DB09N	Data bit 9 - negative
11	WP“N”DB10P	Data bit 10 - positive
31	WP“N”DB10N	Data bit 10 - negative
12	WP“N”DB11P	Data bit 11 - positive
32	WP“N”DB11N	Data bit 11 - negative
13	WP“N”DB12P	Data bit 12 - positive
33	WP“N”DB12N	Data bit 12 - negative
14	WP“N”DB13P	Data bit 13 - positive
34	WP“N”DB13N	Data bit 13 - negative
15	WP“N”DB14P	Data bit 14 - positive
35	WP“N”DB14N	Data bit 14 - negative
16	WP“N”DB15P	Data bit 15 - positive
36	WP“N”DB15N	Data bit 15 - negative
17	WP“N”DB16P	Data bit 16 - positive
37	WP“N”DB16N	Data bit 16 - negative
18	WP“N”DB17P	Data bit 17 - positive
38	WP“N”DB17N	Data bit 17 - negative
19	WP“N”DB18P	Data bit 18 - positive
39	WP“N”DB18N	Data bit 18 - negative
40	NC	No connect

Table 2-1. Pin-Outs (2 of 2)

Pin #	Signal Name[1]	Description
41	NC	No connect
42	NC	No connect
43	NC	No connect
44	NC	No connect
45	WP“N”DB19P	Data bit 19 - positive
65	WP“N”DB19N	Data bit 19 - negative
46	WP“N”DB20P	Data bit 20 - positive
66	WP“N”DB20N	Data bit 20 - negative
47	WP“N”DB21P	Data bit 21 - positive
67	WP“N”DB21N	Data bit 21 - negative
48	WP“N”DB22P	Data bit 22 - positive
68	WP“N”DB22N	Data bit 22 - negative
49	WP“N”DB23P	Data bit 23 LSB - positive
69	WP“N”DB23N	Data bit 23 LSB - negative
50	WP“N”DB24P	Data bit 24 - positive band ID LSB
70	WP“N”DB24N	Data bit 24 - negative band ID LSB
51	WP“N”DB25P	Data bit 25 - positive band ID
71	WP“N”DB25N	Data bit 25 - negative band ID
52	WP“N”DB26P	Data bit 26 - positive band ID
72	WP“N”DB26N	Data bit 26 - negative band ID
53	WP“N”DB27P	Data bit 27 - positive band ID MSB
73	WP“N”DB27N	Data bit 27 - negative band ID MSB
54	WP“N”DB28P	Data bit 28 - positive quadrant LSB
74	WP“N”DB28N	Data bit 28 - negative quadrant LSB
55	WP“N”DB29P	Data bit 29 - positive quadrant MSB
75	WP“N”DB29N	Data bit 29 - negative quadrant MSB
56	WP“N”DB30P	Data bit 30 - positive line start
76	WP“N”DB30N	Data bit 30 - negative line start
57	WP“N”DB31P	Data bit 31 - positive dead column
58	NC	No connect
59	NC	No connect
60	NC	No connect
63	NC	No connect
64	NC	No connect
77	WP“N”DB31N	Data bit 31 - negative dead column
78	NC	No connect
61	WP“N”CLKP	Port clock - positive
62	WP“N”CLKN	Port clock - negative

[1] WP “N” is WARP port, where N equals 1 through 5.

Throughout the WARP and FODB operating range (-10^{o}C to 40^{o}C), the timing skew between any two FODB/WARP RS-422 receivers within the same data port shall not exceed 10 ns.

The 10-ns timing skew maximum is based on 26C31 transmitter and 26C32 receiver test data over various temperatures (-55^{o}C, 25^{o}C, and 125^{o}C), provided by Harris Semiconductor.

2.4.1 Rise Time

The rise time (at the output of the generating source) shall be less than 20 ns, as required by Electrical Characteristics of Balanced Voltage Digital Interface, document EIA-422-B.

2.4.2 Fall Time

The fall time (at the output of the generating source) shall be less than 20 ns, as required by Electrical Characteristics of Balanced Voltage Digital Interface, document EIA-422-B.

2.4.3 Clock Frequency

The ALI's data port clock output rates are as follows: 3.2 MHz (MS/PAN); 4.8 MHz (WIS\GIS VNIR); 9.6 MHz WIS\GIS SWIR.

2.4.4 ALI Port Timing Diagrams

For information on the bit-level timing for data transfers with respect to the port clock, refer to Focal Plane Subsystem to Instrument ICD, MIT/LL document ALI-S1002 (pages 26 and 27). All ALI port timing is further explained in Section 6.2 of the same document (pages 73 - 77).

2.5 Signal Levels

2.5.1 Transmit Levels

Per document EIA-422-B, the differential voltage level at the outputs of the ALI RS-422 transmitters shall be between 2.0 and 6.0 VDC.

2.5.2 Receive Levels

Per document EIA-422-B, received differential signal voltage of greater than +/- 200 mV shall cause the receiving devices to correctly assume the intended binary state.

2.6 Signal Grounding and Isolation

Signal, power, and chassis grounds shall be handled in accordance with the specifications contained in the System Level Electrical Requirements NMP EO-1 Flight, Litton Amecom document AM-149-0020(155). Signal and power grounds return to a single point ground contained within the PSE of the spacecraft. Signal ground is referenced to chassis ground at the output of the secondary power converter of the relevant subsystem.

2.7 Handling Procedures

2.7.1 ESD Precautions

Standard ESD precautions defined at the higher assembly levels for the ALI, the WARP, and the Instrument FODB Terminal apply to this interface.

2.7.2 Connector Installation and Removal

Policies set forth in the Integration and Test (I&T) Plan shall determine the procedures for connector installation and removal.

2.7.3 Maximum Number of Mate-Demates

During testing, connector savers shall be used. The number of mates-demates between the flight harness and the Instrument FODB Terminal (or the WARP RS-422 interface) shall be limited to no more than TBD. Policies set forth in the I&T Plan shall determine the maximum number of mate-demates.

2.8 EMI/EMC/RFI Specifications and Procedures

The RS-422 interface shall conform to the EMI/EMC/RFI specifications and procedures contained within the System Level Electrical Requirements NMP EO-1 Flight, Litton Amecom document AM-149-0020(155).

Section 3. Data Link Layer

3.1 Function

The Data Link Layer defines the basic data units (referred to as words, lines, or frames) that are present on the interface and ensures that these data units are transmitted with minimal errors from the source to the destination. The words are created by adding headers to the data at the source, which are then recognized by the Data Link Layer service in the receiver. These words are required for data transfer management. The other principal function of this layer is flow control: managing the volume of data from source to destination so as to prevent overflow or underflow of the buffers on either end. Both error control and flow control require acknowledgment from receiver to source, and this acknowledgment scheme is defined at this layer.

3.2 Data Unit (Word) Definition

3.2.1 Word Data Area Size

The standard data unit of the ALI RS-422 interface consists of two 12-bit pixels and an 8-bit header. Data bit 0 (DB0) is the most significant bit (MSB) of pixel #1; DB11 is the least significant bit (LSB) of pixel #1; BD12 is the MSB of pixel #2; DB23 is the LSB of pixel #2. The header data spans DB24 through DB31. Figure 3-1 illustrates the ALI word format.

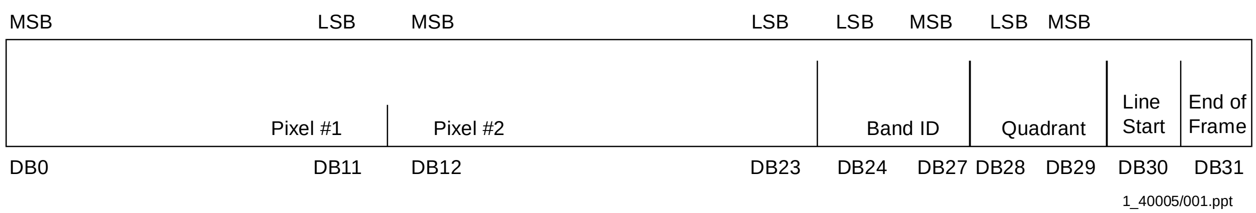


Figure 3-1. ALI Word Format

3.2.2 Word Header Definition

Portions of the science data word header are used to control data flow into the FODB or WARP interfaces. The science data word header is defined in Focal Plane Subsystem to Instrument ICD, MIT/LL document ALI-S1002 (page 40). The science data word header is briefly described in the following subsections.

3.2.2.1 WIS/GIS SWIR: Ports 3 and 5

The BAND ID, bits 24-27, is a 4-bit pattern that indicates the data’s source and is static during data transmission.

The QUADRANT ID, bits 28 and 29, is a 2-bit pattern that identifies the specific quadrant for data which propagates through each WIS/GIS SWIR data port. The QUADRANT ID changes with each port clock and sequentially cycles through a count of 0 through 3.

LINE START (DB30) goes high on the first valid bit for each quadrant and is high “1” for a count of 4 data port clock cycles.

END OF FRAME (DB31) goes high at the end of the integration period (several cycles before the first valid data bit of quadrant 1), and remains high until the last valid data word of quadrant 4.

3.2.2.2 WIS/GIS VNIR: Ports 2 and 4

The BAND ID, bits 24-27, is a 4-bit pattern that indicates the data’s source and is static during data transmission.

The QUADRANT ID, bits 28 and 29, is a 2-bit pattern that identifies the specific quadrant location for data which propagates through each WIS/GIS VNIR data port. The QUADRANT ID changes with each port clock and sequentially cycles through a count of 0 to 1. During data reads, DB29 is static false “0” and DB28 toggles on each data port clock cycle.

LINE START (DB30) goes high on the first valid bit for each quadrant and is high “1” for a count of 2 data port clock cycles.

END OF FRAME (DB31) goes high at the end of the integration period (several cycles before the first valid data bit of quadrant 1), and remains high until the last valid data word of quadrant 2.

3.2.2.3 MS/PAN: Port 1

The MS and PAN data are read through the same ALI data port. The BAND ID, bits 24-27, is a 4-bit pattern that indicates the data’s source and is static during data transmission. Nine discrete patterns identify the MS band. The ALI identifies its three discrete PAN bands with the same pattern.

The QUADRANT ID, bits 28 and 29, is a 2-bit pattern that identifies the specific sensor collection assembly (SCA) for data which propagates through the MS/PAN data port. The QUADRANT ID changes with each port clock and sequentially cycles through a count of 0 through 3: MS SCAs are counts 0 and 1; PAN SCAs are counts 2 and 3. The SCA IDs are listed in Figure 19 of MIT/LL document ALI-S1002.

LINE START (DB30) goes high “1” on the first valid data word of an MS or PAN scene. The MS/PAN data format varies based on science commanding, and there is no way to determine whether the first transmitted word will be MS or PAN data. Header bits DB28 and DB29 must be used with DB30 and DB31 to distinguish valid MS data words from valid PAN data words.

For MS, the END OF FRAME (DB31) goes high at the end of the integration period (several cycles before the first valid data word of SCA 1) and remains high until the last valid pixel data of SCA4. DB31 indicates the end of the MS/PAN data.

For PAN, the END OF FRAME (DB31) goes high at the end of the integration period of SCA1 and remains high until the last valid data word of SCA4.

END OF FRAME (DB31) logically “AND’ed” with LINE START (DB30) yields the first pixel for MS and PAN data. DB29 distinguishes whether the first pixel is MS or PAN. DB29 = 1 identifies the first PAN pixel, and DB29 = 0 identifies the first MS pixel.

3.3 Data Unit Timing and ALI Frame Definition

Data unit timing diagrams, relative to the appropriate port clock, are illustrated in Focal Plane Subsystem to Instrument ICD, MIT/LL document ALI-S1002 (pages 26 and 27). WIS/GIS SWIR port clocks are each 9.6 MHz. WIS/GIS VNIR port clocks are each 4.8 MHz. The MS/PAN port clock is 3.2 MHz.

ALI port frames consist of numerous words, excluding the science data header. MIT/LL document ALI-S1002 (pages 31-39) defines the frame structure for each ALI port.

Section 4. Application Layer

4.1 Function

The Application Layer is the most abstract level of the data. The data here represent the contents of the actual science data issued from the ALI and retained by the FODB/WARP interfaces.

4.2 Science Data Content and Formatting

The WARP and the Instrument FODB Terminal shall remove each science data header, except the MS/PAN, and insert a 96-bit frame synchronization pattern/counter at the beginning of each frame. The frame synchronization pattern identifies the first pixel from the first quadrant for each ALI frame, except the MS/PAN, and appends a 24-bit frame counter. For the MS/PAN, the frame synchronization pattern identifies the first pixel from the MS's SCA 1. MIT/LL document ALI-S1002 (Section 6) contains a more detailed explanation of the ALI data word format, integration timing, frame (line) timing, and data port timing.(see MIT/LL document ALI-S1002 for an illustration of the data format of each ALI port). The WARP-to-Ground ICD contains the downlinked science data format.

When the END OF FRAME header bit (DB31) is true, all ALI port data are not valid. Every valid frame contains "dead words," which are identified in the science data format as ODDREF/EVENREF words for the MS/PAN format and NO DATA words for the VNIR and SWIR. WIS and GIS dead words shall not be recorded. MS and PAN dead words shall be recorded. The WARP or the Instrument FODB Terminal shall count port clocks and disregard dead word counts. The ALI MS/PAN frame (line) rate range supported by the WARP and the Instrument FODB Terminal is from 182 to 239 frames per second. The nominal frame (line) rate supported is 226 frames per second.

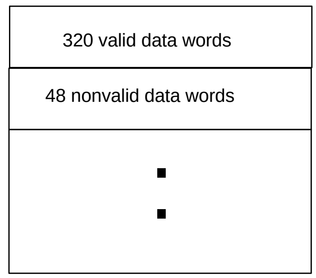
4.2.1 WIS/GIS SWIR: Ports 3 and 5

The SWIR FPAs consist of 320 pixels in the spatial direction and 210 pixels in the spectral direction. The pixels are distributed over four quadrants, each with a dimension of 105 by 160 pixels. Two 12-bit pixels are read out of the four quadrants sequentially on each valid port clock cycle. The WARP and the Instrument FODB Terminal shall insert a 96-bit frame synchronization pattern/counter to identify the first pixel from the first quadrant for each WIS/GIS SWIR frame. The port clock frequency is 9.6 MHz.

Within each frame, nonvalid words are interspersed with the valid data. The science data header bits DB31 and DB30 and a custom word counter will be used by the WARP and the Instrument FODB Terminal to filter dead words from the received ALI data. Data are received from the ALI in 320 valid data port clock samples followed by 48 invalid data port clock samples. Figure 4-1 illustrates the SWIR valid/dead word pattern. The WARP RS-422 and the Instrument FODB Terminal will filter (i.e., not record) the 48 invalid data port clock samples.

The 320 valid data port clock samples equate to 80 counts for each of the four quadrants (320 = 80*4). The 48 invalid data port clock samples equate to 12 counts for each of the four

SWIR Frame Format



Format repeats 105 times

Figure 4-1. SWIR Valid/Dead Word Pattern

quadrants (48 = 12*4). The pattern repeats until 105 valid data blocks, one for each line, is read out (after data format count number 9,648). A total of 38,592 (105*320 + 104*48) data port clock cycles are required to read a single data frame. DB31 goes low “0” at the end of a frame, when the data are not valid.

4.2.2 WIS/GIS VNIR: Ports 2 and 4

The SWIR FPAs consist of 320 pixels in the spatial direction and 105 pixels in the spectral direction. The pixels are distributed over two quadrants, each with a dimension of 105 by 160 pixels. Two 12-bit pixels are read out of the four quadrants sequentially on each valid port clock cycle. The WARP and the Instrument FODB Terminal shall insert a 96-bit frame synchronization pattern/counter to identify the first pixel from the first quadrant for each WIS/GIS SWIR frame. The port clock frequency is 4.8 MHz.

Within each frame, nonvalid words are interspersed with the valid data. The science data header bits DB31 and DB30 and a custom word counter will be used by the WARP and the Instrument FODB Terminal to filter dead words from the received ALI data. Data are received from the ALI in 160 valid data port clock samples followed by 24 invalid data port clock samples. Figure 4-2 illustrates the VNIR valid/dead word pattern. The WARP and the Instrument FODB Terminal will filter (i.e., not record) the 48 invalid data port clock samples.

The 320 valid data port clock samples equate to N=80 counts for each of the four quadrants. The 48 invalid data port clock samples equate to N=12 counts for each of the four quadrants (48 = 12*4). The pattern repeats until 105 valid data blocks, one for each line, is read out. A total of 19,296 (105*160 + 104*24) data port clock cycles are required to read a single data frame. The WARP and the Instrument FODB Terminal will filter (i.e., not record) the 48 invalid data port clock samples. DB31 goes low “0” at the end of a frame, when the data are not valid.

VNIR Frame Format

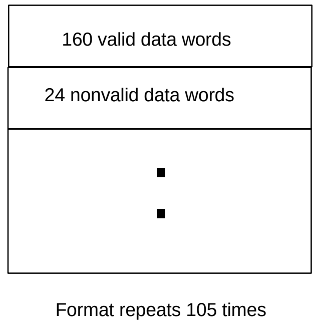


Figure 4-2. VNIR Valid/Dead Word Pattern

4.2.3 MS/PAN: Port 5

The MS and PAN data are multiplexed and transmitted to the WARP\FODB interfaces through a single ALI data port. PAN data are read out three times per frame. MS data is read out once per frame. For each FPE master clock cycle, two MS data words are output followed by two PAN words. Relative alignment of the MS and PAN data streams varies based on science commanding, and there is no way to determine whether the first transmitted word will be MS data or PAN (see Section 3.2.2). Timing diagrams are located in MIT/LL document ALI-S1002. The following subsections describe the MS and PAN formats.

4.2.3.1 MS

The MS FPA consists of four SCAs with 320 pixels in each of nine bands. Four reference pixels are associated with each SCA and each band. Two 12-bit pixels are read out of two SCAs sequentially on each valid MS port clock cycle. The port clock frequency is 3.2 MHz.

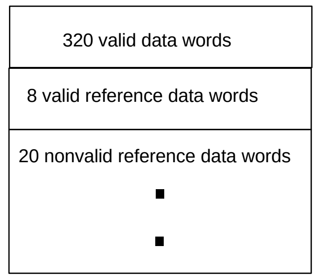
MS data are read out once per frame. Within each frame, nonvalid words are interspersed with the valid data. Data are received from the ALI in 328 valid data port clock samples followed by 20 invalid data port clock samples. The WARP and the Instrument FODB Terminal will record the 20 invalid data port clock samples. The pattern repeats twice for each band. Figure 4-3 illustrates the MS valid/dead word pattern. A total of 6,244 (9 bands *2 blocks/band *328 clocks/block + 8 bands*2 blocks/band*20 clocks/block +1band*20 clocks) data cycles are required to read out the data frame.

The data header bits 24 through 27 indicate the band currently read out and changes state nine times throughout the data readout period. END OF FRAME (DB31) is not a true data valid bit and should be used to indicate the end of the data. DB30 goes high on the first valid data bit for each SCA pair and is high for two data port cycles. DB31 goes low “0” at the end of a frame, when the data are not valid. QUADRANT ID, DB28 and DB29, identifies the currently accessed SCA. DB29 is static false throughout the data read, and DB28 toggles on each port cycle.

Design Review
EO-1 WARP

Instrument Interface

MS Frame Format



Format repeats 18 times

Figure 4-3. MS Valid/Dead Word Pattern

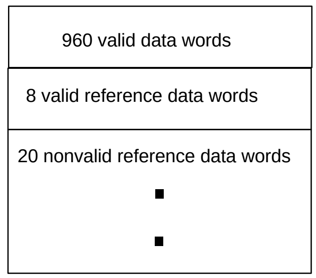
4.2.3.2 PAN

The PAN FPA consists of four SCAs, each with 960 pixels. Four reference pixels are associated with each SCA and each band. Two 12-bit pixels are read out of two SCAs sequentially on each valid PAN port clock cycle. The port clock frequency is 3.2 MHz.

PAN data are read out three times per frame. Within each frame, nonvalid words are interspersed with the valid data. Data are received from the ALI in 968 valid data port clock samples followed by 20 invalid data port clock samples. The WARP and the Instrument FODB Terminal will record the 20 invalid data port clock samples. The cycle repeats two times for each scene readout, for a total of six times during a frame. Figure 4-4 illustrates the PAN valid/dead word pattern.

The data header bits 24 through 27 identify which of the 3 PAN cycles is currently read out. LINE START (DB30) and END OF FRAME (DB31) toggle three cycles each frame, once for each image. DB31 goes high at the end of the integration period, several cycles before the first valid data bit of SCA 1, and remains high until the last valid data bit of SCA 4. DB30 goes high on the first valid data bit for each SCA and is high for two data port cycles. DB31 goes low “0” at the end of a frame, when the data are not valid. QUADRANT ID, DB28 and DB29, identifies the currently accessed SCA. DB29 is static true throughout the data read, and DB28 toggles on each port cycle.

PAN Frame Format



Format repeats 6 times

Figure 4-4. PAN Valid/Dead Word Pattern

Abbreviations and Acronyms

°C	degree Celsius
AC	Atmospheric Corrector
ALI	Advanced Land Imager
DB	data bit
EIA	
EMC	?electromagnetic compatibility?
EMI	
EO-1	Earth Orbiter-1
ESD	
FODB	Fiber Optic Data Bus
FPA	focal plane array
FPE	focal plane electronics
GIS	
GSFC	Goddard Space Flight Center
ICD	interface control document
I&T	integration and test
LEISA	Linear Etalon Imaging Spectral Array
LSB	least significant bit
Mb	megabit
MDM	
MHz	megahertz
MIT/LL	Massachusetts Institute of Technology/Lincoln Laboratory
MS	
MSB	most significant bit
mV	millivolt
NASA	National Aeronautics and Space Administration
NMP	New Millenium Program

ns	nanosecond
OSI	Open Systems Interconnection
PAN	
PSE	?power switching electronics?
RF	radio frequency
RFI	radio frequency interference
SWIR	shortwave infrared
TBD	to be determined
VDC	
VNIR	visible and near infrared
WARP	Wide Band Advanced Recorder/Processor
WIS	